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(54) Invention name AUTOMATIC FREQUENCY GAIN CONTROLLING CIRCUIT (21) Application number 59-253796

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Specification

1. Invention name

Automatic frequency gain controlling circuit

2. Patent application field

(1) Automatic frequency control mixer, which removes the frequency difference in the input reference frequency,

variable gain amplifier, which compensates the output signal level change of the automatic frequency gain controlling circuit,

voltage control oscillator, which provides the local frequency within the mentioned automatic frequency control mixer,

reference detector, which detects the reference waves with the mentioned variable gain amplifier output signal,

sweeping device, which provides the sweeping voltage within the mentioned voltage control sweeping device providing that there is no detection output signal of the mentioned reference detector;

and within the automatic frequency gain controlling circuit of the Satellite communications earth receiver:

initial sweeping medium, which provides the sweeping voltage within the mentioned voltage control oscillator during the initial set-up,

initial level set-up medium, which provides the reference level settings within the mentioned variable gain amplifier during the initial set-up,

digital control medium, which provides the program control of the mentioned initial level set-up medium and the initial sweeping medium having the detection output of the reference detector as an input,

and the automatic frequency gain controlling circuit having all the mentioned above as its main features.

3. Detailed description of the invention

[Technical application field]
The titled invention refers to the development of the automatic frequency gain controlling system of the Satellite communications earth station receiver.

[Conventional technique]

The receiver of the satellite communications earth stations sets the automatic frequency control – automatic gain control (later named AFC and AGC) circuits that provide the automatic gain controlling and automatic frequency controlling, within one circuit; and uses the method to supply the compensation of the frequency difference or level change to the recovery part by applying the AFC or AGC to the sent reference wave (pilot signal etc.). Conventionally, in order to prevent the malfunctioning of the reference detection circuit of the AFC-AGC circuit detecting the reference waves, only one bandpass filter (BPF) was necessary.

Graph 3 is the block structure graph of the conventional AFC-AGC circuit. In according to this graph, the reception signal with the frequency difference or level change is swept by the AFC mixer 1, and then, through the unnecessary wave removing BPF and through the distributor 4 having the level change compensated by the voltage control variable gain amplifier, is sent to the recovery part outside the graph.

From the other side, the other direction output signal within the distributor is inputted to the BPF 5, where it is sent to the AGC detector 7 and AFC BPF 101 by the means of detector 6 extracting only reference waves. The output signal of AFC bandpass filter is distributed to the phase comparator 10 and reference wave detector 12 by the distributor 9. The phase comparator 10 provides the output signal and phase comparison of the local reference signal, where the output signal is sent to AFC controller 102. At the same time, the AFC transfer device 103 transfers the AFC sweep signal from AFC sweeping device to AFC controller 102 output signal side by means of reference wave detector 12 output signal. Output signal of the AFC transfer device 103 is supplied within the voltage control oscillator 18 and sets the AFC local wave frequency.

Nevertheless, regarding the conventional example circuit, AFC bandpass filter 101 is needed to prevent the malfunction of the AFC reference wave sweeping device 12. The necessity of the AFC bandpass filter is explained in below. Now, if we take reception signal static electric density as C/N_0, band of the bandpass filter 5 as B_1 and band of the AFC bandpass filter 101 as B_2, reception signal static electric density within the output signal of the bandpass

filter 5 or AFC bandpass filter 101 as, respectively, C/N_1 and C/N_2, the result will be as follows:

$C/N_1 = C/N_0B_1$ ....(1)

$C/N_2 = C/N_0B_0$ ....(2)

From the other side, the voltage control variable gain amplifier 3, in order to operate the bandpass filter 5 output the in the full electric power, when P_1 is the output of the voltage control variable gain amplifier 3, has the following:

$P_1 = C+N_1$........................(3)

Then, if there is no reception reference signal, and the control field of the voltage control variable gain amplifier is big enough, consequently:

$P_1 = N_1$ ....(4)

On the other hand, when the full electric power of the output of the AFC bandpass filter 101 is P_2,:

$P_2 = C+N_2$ ....(5),

while when there is no reception reference signal:

$P_2' = N_2$

If there were no AFC bandpass filter 101, the electricity input to the reference wave detector by the formulas (3) and (4), irrespective of the reference wave presence, would be P_1, making impossible the detection of the presence of reference waves. In case of using the AFC bandpass filter 101, when there are no reference waves in the output of the AFC bandpass filter 101, the output P_2' will become ($=N_2$) by the formula (6), but this, as shown in the formula below, decreases from the output $P_1(=N_1)$ with the bandpass filter 5 and AFC bandpass filter 101 band proportion being a.

$a = P_2'/P_1 = N_2/N_1 = N_0B_2/N_0B_1 = B_2/B_1$ ....(7)

On the other hand, when there is a reference wave, the bandpass filter 5 and the AFC bandpass filter 101 output proportion ß will be derived by the following formula using formulas (3) and (5).

$ß = P_2/P_1 = C+N_2/C+N_1 = C+N_0B_2/C+N_0B_1=1+N_0B_2/C / 1+N_0B_1/C$ ....(8)

therefore,

$P_2' = aP_1=(B_2/B_1)P_1$ ....(9)

$P_2 = ßP_1 = (1+N_0B_2/C / 1+N_0B_1/C)$ ....(10)

here,

if $P_2>P_2'$

, it would be possible to detect the presence of the reference waves by the reference waves detector.

If $B_1>B_2$

, consequently $P_2>P_2'$

which is to be explained below.

$P_2 - P_2' = (ß - a) P_1 = (1+N_0B_2/C / 1+N_0B_1/C - B_2/B_1) P_1 = (B_1 - B_2 / B_1 (1+N_0B_1/C) P_1$ ....(11)

Here, band B_1, B_2, reception signal electricity C, static electric density N_0 and output P_1 are all positive, so

if $B_1>B_2$,

consequently $P_2>P_2'$.

(Problems solved by the titled invention)

As it was explained in above, the AFC bandpass filter 101 is necessary to prevent the reference wave detector from the malfunctioning within the conventional example

analogue type AFC-AGC circuit. Consequently, the circuit scale grows bigger while the reliance is getting lower.

The titled invention solves the mentioned problem, providing the automatic frequency gain controlling circuit with a small circuit scale and high reliance, enabling the proper functioning of the reference wave detector without using the AFC bandpass filter.

[Technique used to solve the problem]

The titled invention, within the automatic frequency gain controlling circuit of the satellite communications earth station receiver provides the automatic frequency control mixer 1 removing the frequency differences of the input reference waves; the variable gain amplifier compensating the level change of the output signal within the automatic frequency control mixer, the voltage control oscillator 18 applying on the local frequency within the mentioned automatic frequency gain controlling circuit, reference wave detector detecting the reference waves by means of mentioned variable gain amplifier output signal, sweeper applying on the sweep voltage within the voltage control oscillator 18 when there is no detection output of the reference wave detector; and provides the initial sweeping medium performing the sweeping voltage within the mentioned voltage control oscillator 18, initial level set-up medium performing the reference level set-up within the mentioned variable gain amplifier and the digital control medium to program control the initial sweeping medium and initial level set-up medium as input of the mentioned reference wave detector detecting output.

[Operating]

The titled invention provides the proper functioning of the reference wave detector without using the AFC bandpass filter, by means of setting the voltage control of the variable gain amplifier circuit, providing the initial digital sweeping signal within the initial sweeping medium by the digital control medium while there is a detecting output of the reference wave detector during the initial set-up; and providing the control initial sweeping and initial level set-up mediums to enable the proper detecting of the reference waves without malfunctioning of the reference wave detector providing the initial level set-up signal within the initial level set-up medium, by means of program controlled digital control medium.

[Practical example]

Graph 1 is the structure block-scheme of the automatic frequency gain controlling circuit practical example. Graph 2 is the structure block-scheme of the digital AGC circuit. In according to the graph 1, the reception signal with the frequency difference and level change is inputted to the AFC mixer 1 from the outer part. Then, the reception signal with the frequency difference being removed proceeds from the AFC mixer 1 to the voltage controlling variable gain amplifier 3 input through the unnecessary wave removing bandpass filter 2. Again, the reception signal, with the level change compensated, is sent to the outer detector part from the voltage controlling variable gain amplifier 3 through the distributor 4. The other output signals of the distributor 4 are

connected with the bandpass filter 5 input having the reference waves extracted. From the bandpass filter reference waves by means of distributor 6 proceed to the AFC detector 7 or distributor 9. AGC detector 7 output signal proceeds to the digital AGC circuit 8 input shown in graph 2.

Here, the peculiar feature of the titled invention is the digital circuit part marked over by the dotted line. Namely, as the AGC detector 7 output signal proceeds to the analogue digital converter 201 inside the digital AGC circuit 8 shown in the graph 2, the analogue signal is converted to the digital signal. From the analogue digital converter 201, digital output signal is connected to the input of the other side of the AGC transfer device 203 through the AGC digital filter 202 from the analogue digital converter 201. Again, the output signal of the initial level set-up device 203 proceeds to the other input of the AGC transfer device 203. The AGC transfer device 203 selects the output signal from the digital filter 202 or from the initial level set-up device, and then output signal of the AGC transfer device 203 proceeds to the digital analogue converter 204 input. The signal output of the digital analogue converter 204, as it is shown in graph 1, is connected to the voltage control variable gain amplifier 3 control input, where the gain control is provided. Moreover, the output signal of the distributor 9 standard waves and of the local reference oscillator respectively proceeds to each input of the phase comparator 10. Reference wave from the distributor 9 proceeds to the reference wave detector 12 input. The output signal of the phase comparator is connected to the analogue digital converter 13 input, and converted from analogue signal into a digital signal. Digital signal from the analogue

digital converter 13 is connected to the input of the other side of the AFC transfer device 15 through the AFC digital filter 14. The output signal of the AFC digital sweeper 16 proceeds within the other AFC transfer device 15 input. The AFC transfer device provides the selection of the of the output signal from the digital filter 14 and the AFC digital sweeper 16, while AFC transfer device 15 output signal being connected to the digital analogue converter 17, and digital signal being converted into analogue voltage. The analogue output voltage from the digital analogue converter 17 proceeds to the voltage controlling oscillator 18, while AFC local frequency from the voltage controlling oscillator 18 is connected to the AFC mixer 1, and the local frequency difference of the receiver signal is removed.

In the initial state, the AFC transfer device signal 20 proceeds form the digital controller 19 to the AFC transfer device 15, which outputs the selected output signal of the AFC digital sweeper 16. Moreover, the AGC converting signal 22 from the digital controller proceeds to the AGC transfer device 203 shown in a graph 2, and the initial level set-up device 205 output signal is selected. The AGC initial level set-up signal 23 from the digital controller 19 proceeds to the initial level set-up device, where the voltage selecting variable gain amplifier 3 is program set for the maximal gain.

Here, the output signal having the reference waves from the reference wave detector 12 proceeds to the digital controller 19, and then, while AFC digital sweeping control signal 21 being connected from the digital controller 19 to the AFC digital sweeping device 16, set-up frequency sweeping is provided with the local frequency intervals. In case of the sweeping, when, having received the output

signal of the reference wave detector about detecting of the reference waves, the sweeping is finished, and reference waves being analysed. When it is detected that there are reference waves, the AGC initial set-up signal 23 is directed from the digital controller 19 to the initial level set-up device 205 stated in graph 2, with its data being re-set. After this, when the presence of the reference waves is analysed again by the output signal of the reference wave detector 12, once again the initial level set-up device re-setting is provided. If there are no reference waves, the titled functions is kept operating while detects them.

After providing the mentioned initial settings, the AFC digital sweeper 16 provides the sweeping, and if the reference waves within the reference wave detector 12 are detected, reference wave detector 12 output signal is directed to digital controller 19 and from digital controller 19 the AFC transfer device signal 20 is redirected to the AFC transfer device 15, having the output signal of th e AFC digital filter 14 being selected, and the frequency difference of the reception signal removed within the AFC mixer 1. Then, the AGC transfer device signal 22 is connected to the AGC transfer device 203 from the digital controller, and output signal of the AGC digital filter 22 being selected, the level change is compensated within the voltage control variable gain amplifier 3.

Such structure explains the functioning of the automatic frequency gain controlling circuit. The output signal 10 of the phase comparator 10, within the graph 1, is inputted to the analogue digital controller, and after being converted into digital signal, is inputted to the AFC transfer device 15 through the AFC digital filter 14. Then, AFC transfer device 15 provides the selection of the AFC digital sweeper 16

output signal and the AFC digital filter output signal. AFC transfer device 15 output signal, being converted to the analogue voltage by means of digital analogue converter 17, is inputted to the voltage controlling oscillator 18.

On the other hand, the output signal of the AGC detector 7 is inputted to the digital AGC circuit. As indicated in graph 2, AGC detector 7 output signal is inputted to the analogue digital converter 201 and, after being converted to the digital signal, is inputted to the AGC transfer device 203 through the AGC digital filter 202. AGC transfer device 203 provides the selecting of the initial level set-up device 205 output signal and AGC digital filter 202 output signal. Again, the output signal of the AGC transfer device 203 by means of the digital analogue converter 204 is converted into analogue voltage, and inputted to the voltage variable gain amplifier 3.

First of all, within the current digital AGC circuit 8, an AGC transfer device 203 output signal is set to the part of the initial level set-up device 205 by means of AGC transfer device signal 22, and the voltage controlling variable gain amplifier is set for a maximal gain by means of the initial level set-up device signal 23 of the initial level set-up device 205 data.

From the other side, in according to graph 1, the AFC transfer device 15 is selects the AFC digital sweeper 16 part by means of AFC transfer device signal 20, and the digital controller 19, in case when the reference wave presence is described by the reference wave detector 12 output signal, provides the preset circuit sweeping with a preset frequency intervals by means of AFC digital sweeping control signal 21. Within such sweeping, the digital controller 19 examines the reference wave detector

12 output signal and frequently discriminates the presence of the reference waves by the majority of the decision after the sweeping finished. As a result, if there are any reference waves detected, even if the reference waves do not enter the bandpass filter 5, reference wave detector determines the malfunctioning by the static noise, and, consequently, the digital controller 19 resets the initial level set-up device 205 data part within the digital AGC circuit 8 using the AGC initial set-up signal 23. After this, if there are still reference waves detected by the reference wave detector output signal, the re-setting of the initial set-up device 205 data part is provided again by means of reference wave detector 12 output signal. This operation will be repeated until there are no reference waves detected by the output signal of the reference wave detector 12. Generally, the hysteresis characteristics is used within the reference wave detector, so, in case of the voltage controlling variable gain amplifier 3 level lowered once detecting reference wave, there is no malfunctioning provided by the reference wave detector 12 due to the static noise. In such condition, it is possible to provide the proper functioning of the reference wave detector 12 in case of the reference waves entered the band of the bandpass filter 5 by providing the sweeping by the AFC digital sweeper 16.

On the other hand, in case of the absence of reference wav es is decided by the major decision, when the initial wave presence is described, accidentally there are some reference waves within the bandpass filter 5, and it is indicated that there are no reference waves when they were directed to the outer part of the band of the bandpass filter 5.

This signifies that there would be no malfunctioning provided by the reference wave detector 12 due to the static noise in case when there are no waves inside the band of the bandpass filter 5. Consequently, if the sweeping with such level set-up of the voltage controlling variable gain amplifier 3 is provided, proper detection of the reference waves is possible. Again, when the output signal of the reference wave detector 12 describes that there are no reference waves within the initial condition, reference wave detector 12 does not malfunction due to the static noise, and immediately the sweeping operation is provided by the AFC transfer device signal 20 from the digital controller and by the AFC digital sweeping control signal 21.

[Results of the titled invention]

As it was explained in above, the titled invention gives the remarkable results of the proper functioning of the reference wave detector without using the AFC bandpass filter, by means of setting up appropriately the gain of variable gain amplifier program controlling the AFC digital sweeper and digital AGC circuit by the digital controller during the initial set-up. Consequently, it is possible to gain high reliance within the small-scale circuit.

4. Graph brief explanation

Graph 1 is a block structure graph indicating the titled invention practical example of the automatic frequency gain controlling circuit.

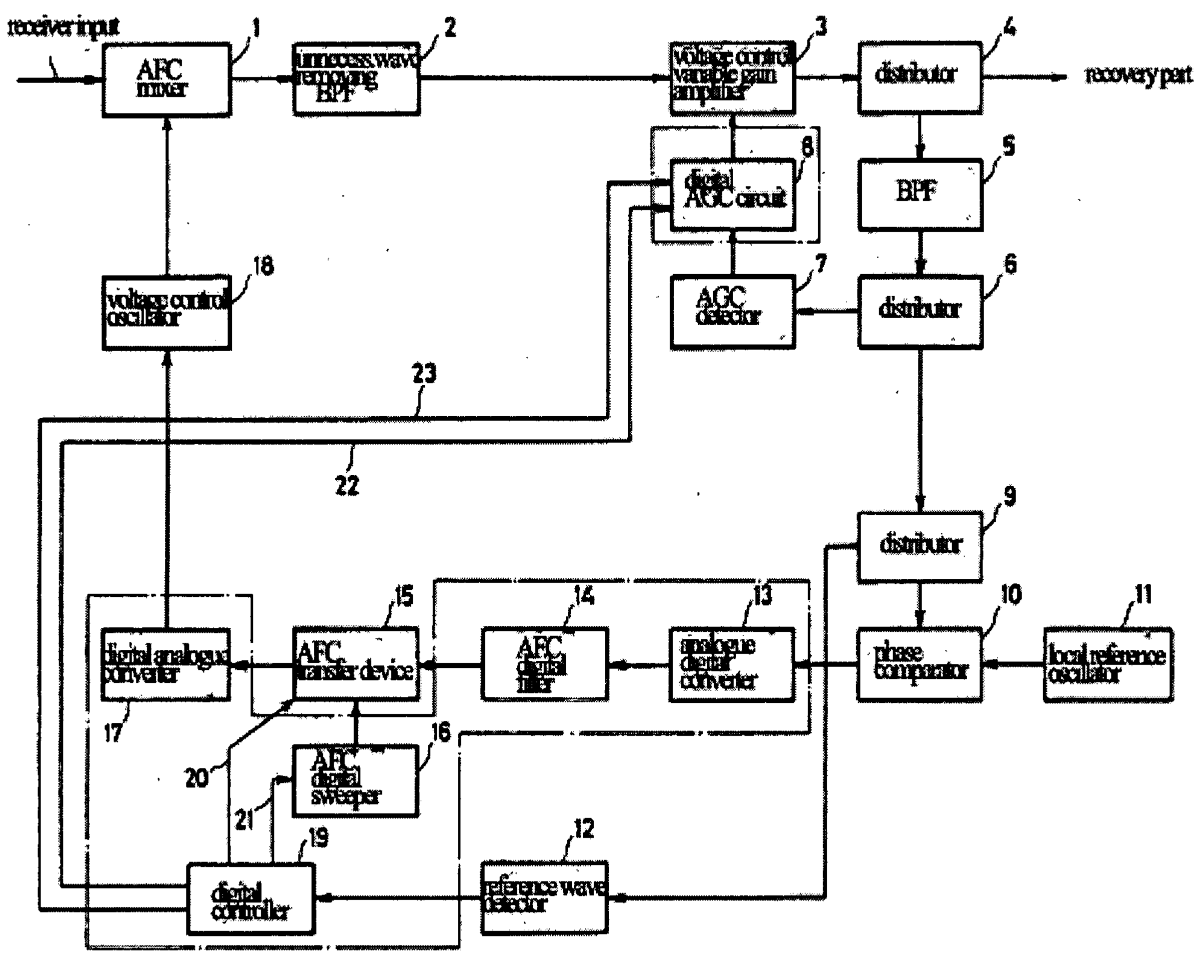
Graph 2 is a block structure graph indicating the digital automatic gain controlling circuit.

Graph 3 is a block structure graph indicating the conventional example of the automatic frequency gain controlling circuit.

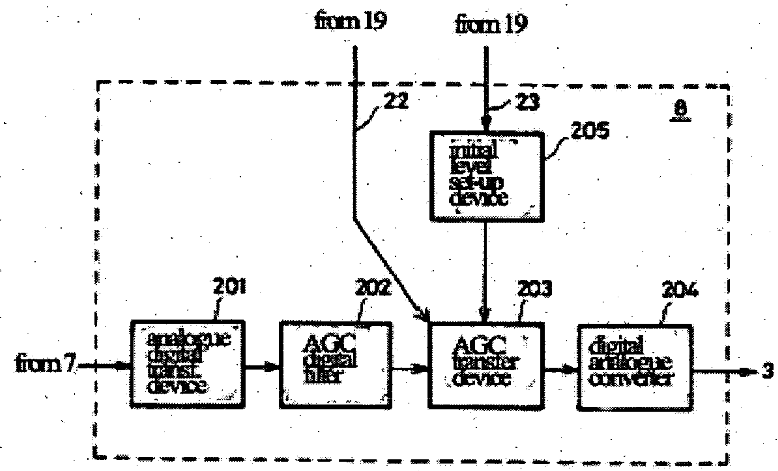
1. AFC mixer, 2. unnecessary wave removing bandpass filter, 3. voltage controlling variable gain amplifier, 4. distributor, 5. bandpass filter, 6. distributor, 7. AGC detector, 8. digital AGC circuit, 9. distributor, 10. phase comparator, 11. local reference oscillator, 12. reference wave detector, 13. analogue digital converter, 14. AFC digital filter, 15. AFC transfer device, 16. AFC digital sweeper, 17. digital analogue converter, 18. voltage controlling oscillator, 19. digital controller, 20. AFC transfer device signal, 21. AFC digital sweeping controlling signal, 22. AGC converter signal, 23. AGC initial level set-up signal, 101. AFC bandpass filter, 102. AFC controller, 103. AFC transfer device, 104. AFC sweeper, 201. analogue digital converter, 202. AC digital filter, 203. AGC transfer device, 204. digital analogue converter, 205. initial level set-up device

Applicant NEC Corp

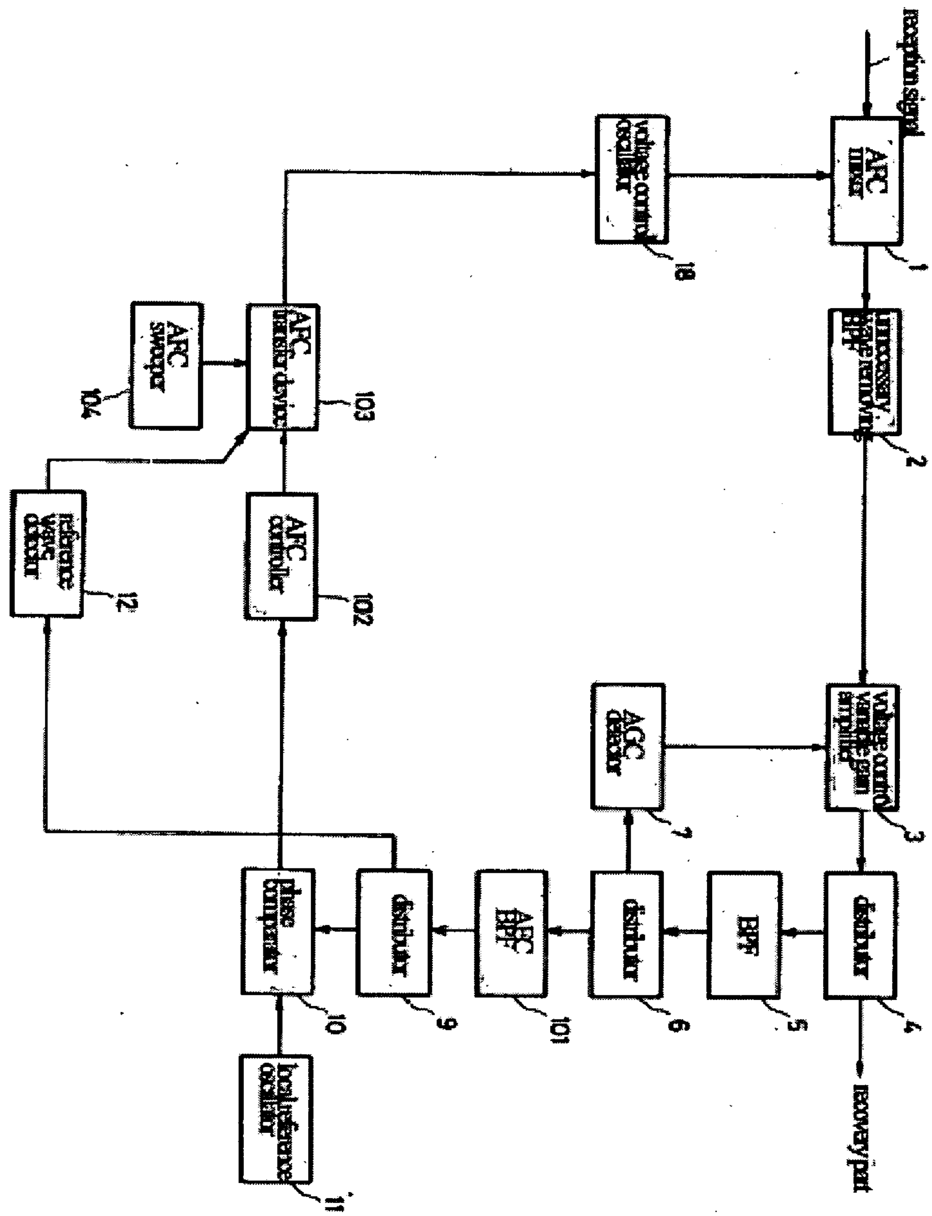
Representative ISYUTU NAOTAKA, patent attorney


receiver input
AFC mixer
1
unnecess.wave removing BPF
2
voltage control variable gain amplifier
3
distributor
4
recovery part
digital AGC circuit
8
BPF
5
voltage control oscillator
18
AGC detector
7
distributor
6
23
22
distributor
9
15
14
13
10
11
digital analogue converter
AFC transfer device
AFC digital filter
analogue digital converter
phase comparator
local reference oscillator
17
16
20
AFC digital sweeper
21
19
12
digital controller
reference wave detector

graph 1


from 19
from 19
22
23
8
205
initial
level
set-up
device
201
202
203
204
from 7
analogue
digital
transf.
device
AGC
digital
filter
AGC
transfer
device
digital
converter
3

graph 2


reception signal
AFC mixer
1
unnecessary wave removing BPF
2
voltage control variable gain amplifier
3
distributor
4
recovery part
BPF
5
distributor
6
AGC detector
7
AFC BPF
101
distributor
9
phase comparator
10
local reference oscillator
11
AFC controller
102
AFC transfer device
103
AFC sweeper
104
reference wave detector
12
voltage control oscillator
18

graph 3